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The latest information for designing full-depth asphalt pavements for parking lots and driveways is covered in relationship to the continued increase in vehicle registration. It is based on The Asphalt Institute's Thickness Design Manual, Series No. 1 (MS-1), Seventh Edition, which covers all aspects of asphalt pavement thickness design in detail, utilizing the latest, computer-derived information from pavement tests here and abroad. The pavement cross-sections given are for typical conditions. Tables, drawings, and photographs are included. (RK)

FULL-DEPTH ASPHALT PAVEMENTS FOR PARKING LOTS AND DRIVEWAYS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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OCTOBER 1967
THE ASPHALT INSTITUTE
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THE PARKING PICTURE

Passenger Cars

In most areas of concentrated population around the world, parking space for motor vehicles is at a premium. In 1966, over 94 million vehicles were registered in the United States, with no sign of any let-up in registration growth. With similar growth being experienced throughout the world, it is likely that the need for more parking space will continue indefinitely.

And so, parking area construction booms. Private and municipal car-parks now provide an estimated 7 million off-street spaces in American cities of 10,000 population or more. In the burgeoning suburban developments asphalt-paved expanses are accommodating the automobiles of thousands of shoppers and business people, and of commuters who transfer to public transportation into the cities. And, in the downtown areas, the number of parking spaces is constantly increasing as old buildings are razed to make room for automobiles. Although multistory parking garages are becoming popular because they conserve valuable space, open lots still constitute nearly two-thirds of all off-street parking.

Trucks

In addition to the parking requirements of light vehicles, ever increasing use of trucks has amplified the need for heavy-duty parking facilities. Modern Full-Depth asphalt pavement is today's practical answer to the rugged demands of heavy truck traffic.

THE DRIVEWAY PICTURE

Residential

Each year thousands of smooth, attractive asphalt-paved driveways are constructed in residential areas throughout the world. Asphalt driveways, in fact, are widely preferred with the construction of new homes. They are easy and economical to build, and in almost every area there are contractors and materials available to build them. They lend charm and utility to any homesite at reasonable cost.

Commercial

Asphalt driveways also serve our existing and developing industries. Access and in-plant asphalt driveways have a record of excellent service and are readily adaptable to modifications made necessary by expansion of commercial facilities.

NOTE: ***This publication pertains to open-air parking lots and driveways built on ground, not to paving on decks of structures.***

SOME REASONS WHY ASPHALT PAVEMENTS ARE SUPERIOR FOR PARKING LOTS AND DRIVEWAYS:

Asphalt pavement versatility permits construction that will meet the needs and conditions of any area.

Asphalt pavements are economical and quickly constructed.

They are durable—performance is excellent and maintenance is low.

Asphalt pavements permit stage construction. They can be strengthened in depth and widened as need arises. Each successive pavement layer, or stage, becomes an integral part of the entire pavement structure and substantially increases its load-carrying capacity.

Snow melts faster on asphalt pavements, and snow- and ice-removal chemicals don't harm them.

Asphalt pavements can be trenched and patched easily when utility lines under the pavement need repair.

There is greater visibility of striping and other traffic markings on asphalt pavements.

Asphalt paving is smooth and continuous; it has no annoying joints.

DESIGN BASIS

This booklet embodies the latest information for designing Full-Depth asphalt pavements for parking lots and driveways. It is based on The Asphalt Institute's *Thickness Design* manual, Manual Series No. 1 (MS-1), Seventh Edition, which covers all aspects of asphalt pavement thickness design in detail, utilizing the latest, computer-derived information from pavement tests here and abroad.

The pavement cross-sections given in this booklet are for typical conditions. For exceptional conditions, you are urged to consult the *Thickness Design* manual (MS-1) where you will find design procedures covering any situation. Manual MS-1 and assistance in pavement design are available at the nearest Asphalt Institute office (see list, back cover).

NOTES TO THE OWNER (ENGINEER):

1. This specification applies to paving jobs of less than 5,000 square yards. For projects of larger area, specifications similar to those in *Specifications and Construction Methods for Asphalt Concrete and Other Plant Mix Types*, SS-1, The Asphalt Institute, should be used.

2. This specification is applicable for such small paving jobs as
   Parking Areas (5,000 square yards or less)
   Driveways.

3. Full-Depth asphalt pavements are recommended for greatest strength and durability. If granular bases are used, specification should meet the requirement of local, state, county, city or other agency.

4. *Article 2. Establishment of Grades*—If the contractor is to establish the grades delete "will be" and "owner" wherever they appear in the first sentence. If the owner is to establish the grades delete "shall be" and "contractor."

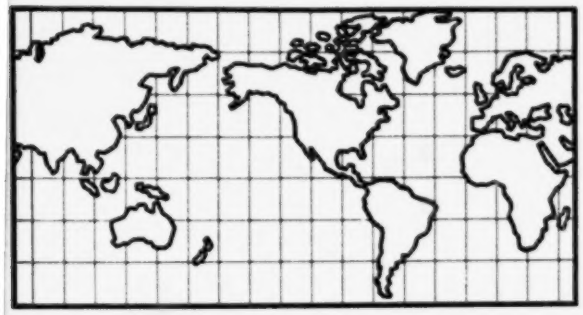
5. *Article 3. Preparation of Subgrade*—Commercial sterilants containing chemical compounds such as sodium chlorate, borate, or arsenate will prevent the germination of weed seeds in the subgrade.

6. *Article 5. Tack Coat*—From 0.05 to 0.15 gallon of diluted SS-1 or SS-1h asphalt emulsion is recommended. The asphalt emulsion should be diluted with equal parts of water.

7. *Article 6.* Equipment—If the job is under the supervision of an engineer, the engineer should approve those pieces of equipment applicable to the job to which the specification will apply.

8. *Article 9. Asphalt Materials*—The type and grade of asphalt material may be selected from Table I-1, *The Asphalt Handbook*, MS-4, The Asphalt Institute.

9. *Article 10. Mineral Aggregate—Asphalt Plant-Mix Base and Surface*—(2) Asphalt Institute Mix Type IVa or Mix Type IVb are recommended gradations. These and other satisfactory mix types are tabulated in *Specifications and Construction Methods for Asphalt Concrete and Other Plant-Mix Types*, SS-1, The Asphalt Institute. Asphalt mixes specified by local public agencies may be used if they have a history of satisfactory performance.



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FACTORS AFFECTING DESIGN

The three principal factors which affect the design of an asphalt pavement structure are:

A. Traffic—Weight and Volume
B. Subgrade Support
C. Properties of Materials in the Pavement Structure

TRAFFIC—The simplified design approach in this booklet is based on two types of traffic: (1) passenger cars, (2) trucks. The pavement thicknesses for passenger cars are adequate to support the infrequent delivery trucks in driveways and light-weight trucks in parking lots. Increased pavement thicknesses, however, should be incorporated in the portions of passenger car parking lots used by heavier trucks. The thicknesses given in Table II are based on use by light to medium weight supply and delivery trucks and occasional heavy trucks. For large volumes of heavy trucks, loaded at or near the legal axle load limit, the design procedures detailed in the *Thickness Design* manual (MS-1) should be followed.

SUBGRADE—It is desirable to use laboratory tests to evaluate the load-supporting characteristics of subgrade soils, and if test equipment is available it should be used. However, if laboratory test equipment is not available, designs may be made on the basis of a careful field evaluation by an engineer who can assign the subgrade soils to one of the following categories:*

1. **Good to excellent** subgrade soils. *Good* subgrade soils retain a substantial amount of their load-supporting capacity when wet. Included are the clean sands and sand-gravels and soils free of detrimental amounts of plastic materials. *Excellent* subgrade soils are unaffected by moisture or frost. They include clean and sharp sands and gravels, particularly those that are well graded.
2. **Medium** subgrade soils which retain a moderate degree of firmness under adverse moisture conditions. Included are such soils as loams, silty sands, and sand-gravels containing moderate amounts of clay and fine silt.
3. **Poor** subgrade soils which become quite soft and plastic when wet. Included are those soils having appreciable amounts of clay and fine silt. The coarser silts and sandy loams also may exhibit poor bearing properties in areas where frost penetration into the subgrade is a factor.

MATERIALS IN PAVEMENT STRUCTURE—Given any combination of traffic and subgrade soil, how thick to design a pavement structure then depends upon the characteristics of materials in the structure. Because of uniform high strength, waterproofness, resistance to frost, and other factors, full-depth asphalt concrete construction permits design of a structure of minimum thickness.

Asphalt Concrete is a high-quality, thoroughly controlled hot mixture of asphalt cement and well-graded, high-quality aggregate, thoroughly compacted into a uniform dense mass typified by Asphalt Institute Type IV Mixes (see *Specifications and Construction Methods for Asphalt Concrete and Other Plant-Mix Types* [SS-1], or *The Asphalt Handbook* [MS-4], The Asphalt Institute). If information about mix design is needed, refer to The Asphalt Institute's *Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types* (MS-2).** Mixing plants capable of making asphalt concrete mixes meeting specifications for state highway work normally are capable of furnishing asphalt concrete mixes as defined above.

* The Asphalt Institute's *Soils Manual for Design of Asphalt Pavement Structures* Manual Series No. 10 (MS-10), describes in detail the more commonly used soil evaluation systems. Field evaluation of the soil involves visual inspection and simple field tests.

** For suggested grades of asphalt cement for different climates see Table 1-2 in *The Asphalt Handbook*.

PAVEMENT THICKNESS

These pages show thickness, both in tables and in cross-section drawings, which normally satisfy

TABLE I

TYPICAL SECTIONS / PARKING LOTS AND DRIVEWAYS FOR PASSENGER CARS (DTN = 1)*

Thicknesses in Inches

SUBGRADE (SEE DESCRIPTION, PAGE 5)	FULL DEPTH ASPHALT CONCRETE	
	SURFACE COURSE [1] (Minimum)	BASE COURSE [1] [2]
GOOD TO EXCELLENT (CBR = 15)**	1 in.	2 ½ in.
MEDIUM (CBR = 7)**	1 in.	3 ½ in.
POOR (CBR = 3.5)**	1 in.	5 in.

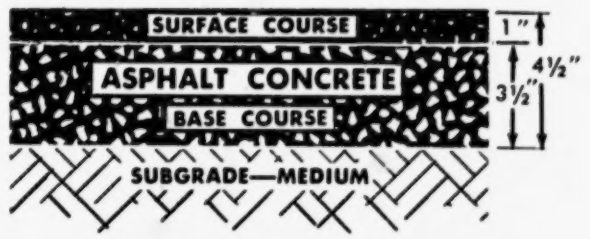
Thicknesses less than those shown in this table may be used where experience has proved them completely adequate. Thicknesses greater than these may be required in some areas.

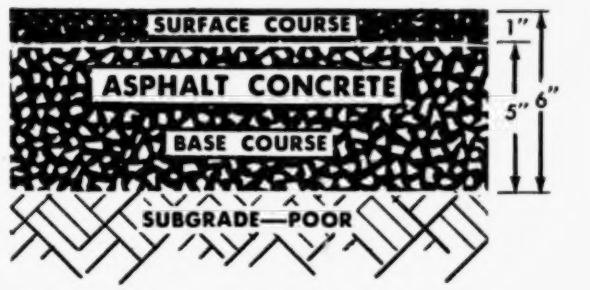
[1] The same asphalt concrete mix that is used for the surface course may be used for the base course.

[2] Asphalt prime may be needed on loosely bonded subgrade. (See *Asphalt Surface Treatments and Asphalt Penetration Macadam* [MS-13], The Asphalt Institute, for details on asphalt prime.)

*Design Traffic Number (DTN) selected to represent traffic normally using parking lots and driveways for passenger cars (see Chapter II, *Thickness Design—Asphalt Pavement Structures for Highways and Streets*, Manual Series No. 1, The Asphalt Institute).

**Approximate middle of CBR ranges selected for differentiating between Good to Excellent (CBR = 9+), Medium (CBR = 5-9), and Poor (CBR = 2-5) subgrades.





the varying conditions of traffic and subgrade support previously described.

TABLE II

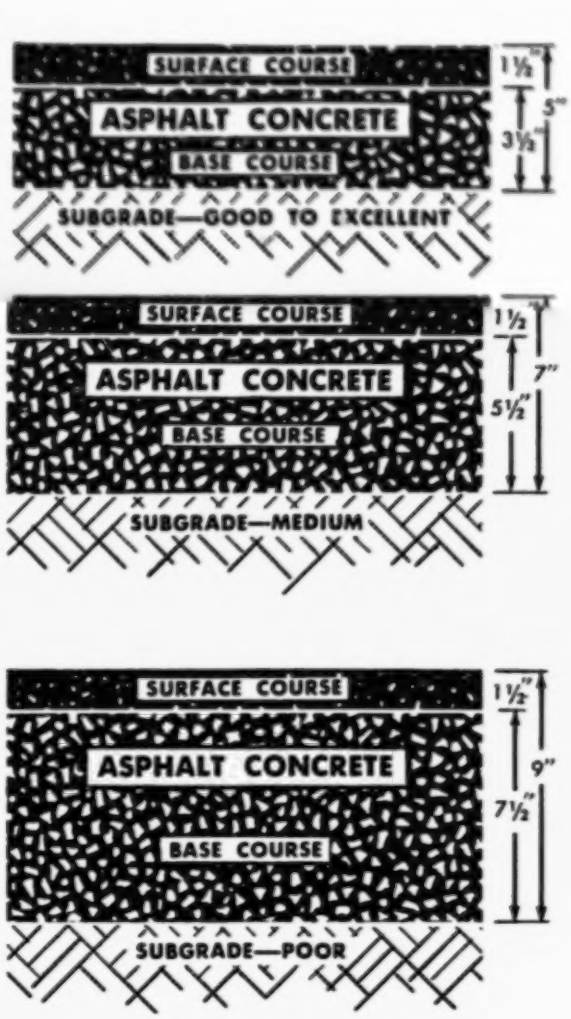
TYPICAL SECTIONS / PARKING LOTS AND DRIVEWAYS FOR TRUCKS (DTN = 20)*

Thicknesses in Inches

SUBGRADE (SEE DESCRIPTION, PAGE 5)	FULL DEPTH ASPHALT CONCRETE	
	SURFACE COURSE (Minimum)	BASE COURSE [1] [2]
GOOD TO EXCELLENT (CBR = 15)**	1½ in.	3½ in.
MEDIUM (CBR = 7)**	1½ in.	5½ in.
POOR (CBR = 3.5)**	1½ in.	7½ in.

Thicknesses less than those shown in this table may be used where experience has proved them completely adequate. Thicknesses greater than these may be required in some areas.

The thicknesses in this table are based on use by light to medium-weight supply and delivery trucks and occasional heavy trucks. For large volumes of heavy trucks, loaded at or near the legal axle load limit, The Asphalt Institute's *Thickness Design* manual, Manual Series No. 1 (MS-1), should be used to design parking lot and driveway pavements.



[1] The same asphalt concrete mix that is used for the surface course may be used for the base course.

[2] Asphalt prime may be needed on loosely bonded subgrade. (See *Asphalt Surface Treatments and Asphalt Penetration Macadam* [MS-13], The Asphalt Institute, for details on asphalt prime.)

*Design Traffic Number (DTN) selected to represent traffic normally using parking lots and driveways for passenger cars (see Chapter II, *Thickness Design—Asphalt Pavement Structures for Highways and Streets*, Manual Series No. 1, The Asphalt Institute).

**Approximate middle of CBR ranges selected for differentiating between Good to Excellent (CBR = 9+), Medium (CBR = 5-9), and Poor (CBR = 2-5) subgrades.

NOTE:

On some parking lots where heavily-loaded truck trailers are stored, the small dolly wheels, lowered when the tractor is removed, may indent the pavement surface. Although an asphalt mix can be designed to support this extremely high-pressure loading, a more economical solution is to place a plank under each set of dolly wheels. This plank should be approximately 10 inches wide, 36 inches long, and 2 inches thick.

Above thicknesses should be increased approximately 20 percent for pavements subjected to large volumes of heavily-loaded trucks, such as truck stops, unloading areas, and truck lanes in parking lots.

CONTRACTORS AND CONSTRUCTION KNOW-HOW

Local asphalt paving contractors are familiar with the materials that perform best under local conditions and are experienced in methods of constructing asphalt pavements. Pavement designers may wish to call on them for their advice on local materials and construction practice (see the Yellow Pages of your telephone book).

OTHER TYPES OF ASPHALT CONSTRUCTION

Asphalt pavement construction is so versatile that several types of asphalt mixtures other than asphalt concrete (see definition page 5) often are suitable for base under certain economic, traffic, climatic, and construction conditions. These include hot-laid plant mix, cold-laid plant mix, hot-mixed asphalt macadam, and hot-mixed sand asphalt. Strength evaluation for these mixtures is presently under study. Until definite strength values are obtained from the studies, users must be guided by local experience with them. State highway engineers and Asphalt Institute engineers are experienced in the use of these other types and are familiar with the thicknesses required for local conditions of traffic and climate. They should be consulted if you are considering the use of any of these other types of asphalt mixes.

For information on appropriate use of plant mix with asphalt cement and liquid asphalt and for details on materials, aggregate gradations, proportions, and methods, see *Specifications and Construction Methods for Asphalt Concrete and Other Plant-Mix Types* (SS-1) and *Hot-Mix Sand Asphalt Base—An Advisory* (Misc. 67-2) The Asphalt Institute.

NOTE: ***All Asphalt Institute literature is obtainable from the nearest Institute office (see back cover).***

COMPACTION

Subgrade

Special attention should be given to subgrade preparation to assure proper compaction. The best method for controlling compaction is through the use of limits and testing procedures recommended in *Thickness Design* manual (MS-1), and detailed in *Soils Manual for Design of Asphalt Pavement Structures* (MS-10), The Asphalt Institute. If these tests cannot be made, a heavily loaded truck should be driven over the subgrade and deflections noted.

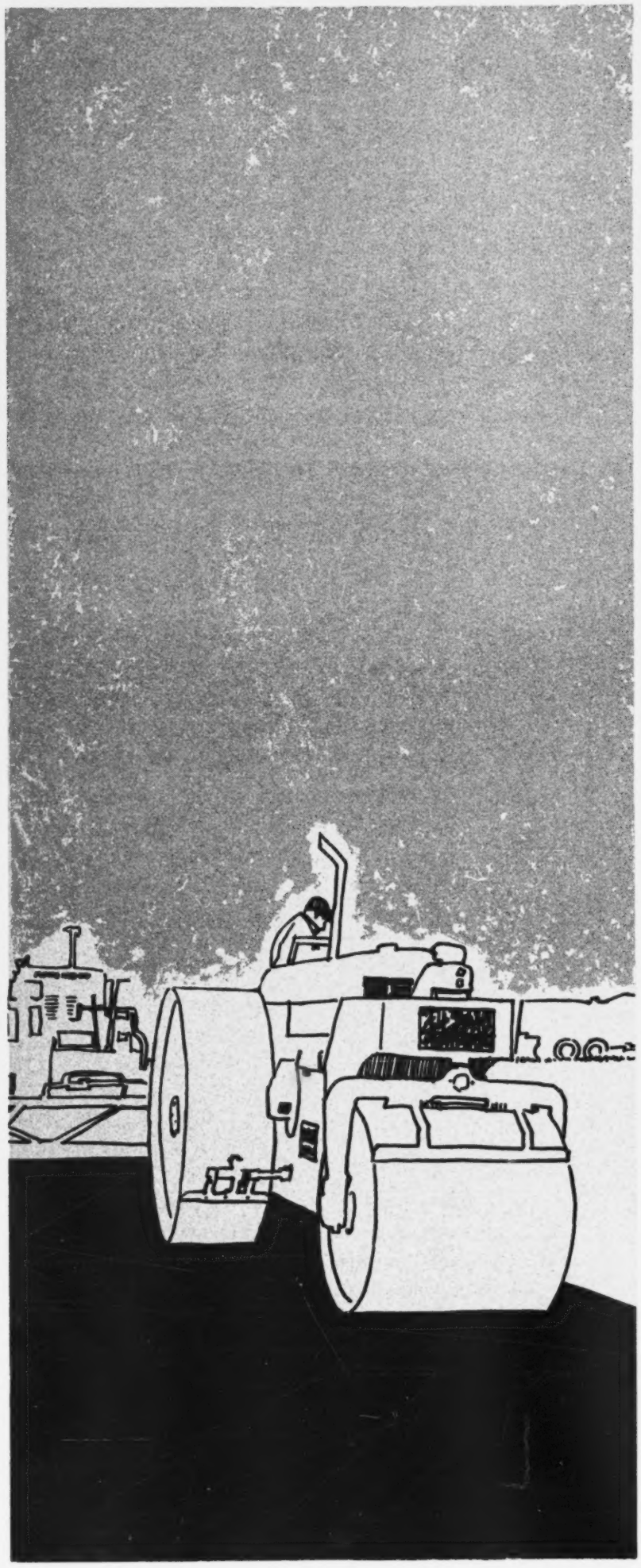
If an area shows pronounced deflection, it has not been adequately compacted and either has not been rolled enough or the soil-moisture content is too high. If additional rolling does not correct the unstable condition, the subgrade should be scarified to a depth of at least six inches, aerated, recompacted, and retested to assure uniform compaction. In some cases it may be necessary to remove the upper portion of the subgrade and replace it with select material.

Pavements

For parking lots and driveways of a size that permits its use, a pneumatic-tired roller should be employed in addition to the steel-wheeled roller to assure proper compaction of the asphalt pavement. Contact pressure of the roller tires should equal that of the majority of vehicles expected to use the parking lot or driveway.

NOTE:

It is good practice to sterilize the subgrade soil before placing the overlying layers. Commercial sterilants containing chemical compounds such as sodium chlorate, borate, or arsenate will prevent the germination of weed seeds in the subgrade.



DEEP-LIFT CONSTRUCTION

Placing hot-mix asphalt base course in a single lift offers several advantages:

1. Because the thicker layer holds heat longer
   (a) it is easier to achieve the required density and
   (b) the mixture can be placed in cooler weather than with thin lifts.
2. The single operation in placing a deep lift is more economical than the two or more required to place the same thickness in thin lifts.
3. Asphalt base course can be placed directly on the prepared subgrade without the resulting distortion and cracking that may occur while rolling a thin lift.

Deep-lift asphalt bases are placed and compacted with conventional paving equipment. Ordinary rock-spreaders can be used to spread the asphalt base mixture if the asphalt paver will not place the material in the thickness desired. It is necessary to begin rolling with low contact pressures and increase them as compaction progresses.

PLANNED STAGE CONSTRUCTION

In many situations, building parking area pavements by stages makes good economical sense. Asphalt paving lends itself to this kind of construction.

Stage construction is not maintenance. It simply means that the pavement design is prepared as described in this booklet, with the asphalt base courses placed as Stage 1. Then the final surfacing (Stage 2) is applied at a later date, depending upon circumstances.

Stage construction has the advantage of providing a thoroughly adequate, all-weather pavement for the initial development of an area. Any damage to the Stage 1 pavement caused by traffic, settlements, or utility tear-ups can be repaired prior to placement of the final surface. With proper asphalt tack coat, where needed, the Stage 2 pavement bonds to the old surface and becomes an integral part of the entire pavement structure.

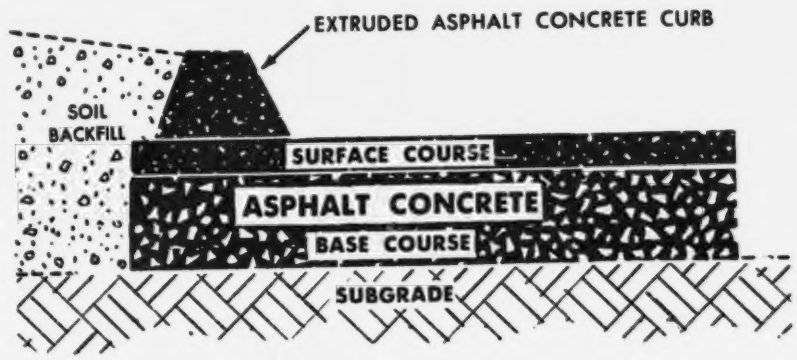
An example of stage construction is:

Stage 1—Asphalt concrete base **Stage 2**—Asphalt concrete surface

but there are others.

ASPHALT CURBS

Asphalt curbs are economical to build, they give excellent service and are pleasing in appearance. In addition to controlling surface water, they are used frequently as dividers to channel traffic into and out of parking lots and as area delineators. They are constructed easily and rapidly without forms, and if it becomes necessary to expand or alter the parking area they can be removed with little difficulty. For details on asphalt curb construction, refer to The Asphalt Institute's *Specifications and Construction Methods for Asphalt Curbs and Gutters* (SS-3).



DRAINAGE

PARKING LOTS—Good surface drainage is absolutely essential for successful parking lot construction. With a proper cross-section it is possible to provide quick surface water run-off either to the outer limits of the paved area, to a shallow gutter through the center, or to drop inlets placed with appropriate spacing so that no standing water will be left on the surface.

To provide for rapid surface drainage, the slope to all drop inlets or gutters should be not less than ¼ inch to the foot.

DRIVEWAYS—In asphalt driveway construction good drainage is highly desirable. The driveway should be sloped or crowned not less than ¼ inch to the foot so all surface water will drain off. Roof drainage from downspouts should, if possible, be piped well away from the edge of the driveway.

WEATHER CONDITIONS

It is always good construction practice to place pavements only when weather conditions are favorable. When there is free water on the surface to be paved, construction should be suspended until the surface is dry.

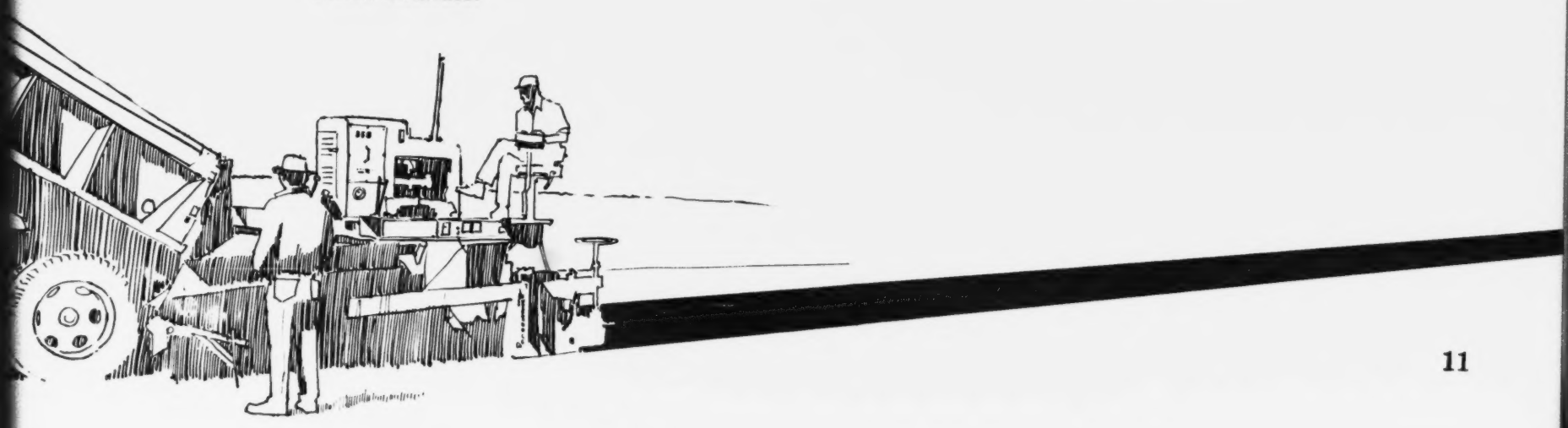
When it is necessary to proceed with construction in cold weather, all loads of asphalt mixtures should be delivered in covered and insulated trucks. And the mixture should be spread and compacted immediately upon arrival at the job site.

MAINTENANCE

Asphalt pavements are easy to maintain—especially pavements constructed of asphalt concrete which last for years with little or no repair. Renewal of the surface, when necessary, may be accomplished rapidly and economically with minimum interference to traffic. An asphalt seal coat—a light application of asphalt and stone chips—will quickly waterproof the pavement and improve its surface appearance.

FUTURE STRENGTHENING

One of the advantages of asphalt pavements is the ease with which it can be strengthened to handle heavier loads or increased traffic. An asphalt concrete overlay placed at a thickness designed for the traffic condition will add many years of service to the existing parking lot or driveway. A bonus from a strengthening overlay is a new smooth, skid-and-water-resistant surface.



SPECIFICATIONS FOR PAVING A _____ WITH ASPHALT CONCRETE

1. *Scope:* Furnish and construct a Full-Depth asphalt pavement structure for a _____ _____ as specified.

A. *General Requirements*

2. *Establishment of Grades:* Grades shall be (will be) established by the contractor (owner) and the grade stakes shall be (will be) set to the desired section by the contractor (owner). In establishing the grades due allowances shall be (will be) made for existing improvements, proper drainage, adjoining property rights and good appearance.

3. *Preparation of Subgrade:* All debris, vegetation, or other perishable materials shall be removed from the job site. The site to be paved shall be graded to the required section and all excess material removed from the location of the work. Material in soft spots shall be removed to the depth required to provide a firm foundation and shall be replaced with a material equal to the best subgrade material on the site. If the subgrade is loosely bonded, it shall be primed with an asphalt priming material. The entire subgrade area shall be compacted at the lowest moisture content at which a handful of the soil can be molded by a firm closing of the hand. The subgrade shall be compacted with at least 5 coverages of a pneumatic-tired roller. The surface of the subgrade after compaction shall be hard, uniform, smooth, and true to grade and cross-section. If directed by the owner or his engineer prior to placing the base course, designated subgrade areas shall be treated with a soil sterilant to prevent the growth of weeds.

4. *Thickness of Structure:* On the prepared subgrade a plant-mixed asphalt base shall be laid in _____ course(s) to a compacted thickness of _____ inches. Placing of the plant-mixed asphalt surface course shall follow and be laid in a single course to a compacted thickness of _____ inches.

5. *Tack Coat:* If directed by the owner (engineer), a tack coat shall be applied on each layer of the base course. The tack coat shall be _____ asphalt applied at the rate of _____ gallon per square yard.

6. *Equipment:* The contractor shall provide the necessary equipment to complete the job acceptable to the owner. Variations in the size and amount of equipment will depend on the size of the area being paved.

7. *Sampling and Testing:* If requested by the owner (engineer) the contractor shall furnish for test and analysis representative samples of the materials to be used in the work. Sampling and testing shall be in accordance with the latest revisions of the American Association of State Highway Officials (AASHO) or the American Society for Testing and Materials (ASTM) Standard procedures for sampling and testing the materials being used in the project.
8. *Smoothness:* The surface of the completed work, when tested with a ten-(10) foot straightedge, shall not contain irregularities in excess of ¼ inch.

B. *Materials*

9. *Asphalt Materials:* The asphalt material for the plant mix shall be (*type and grade*) as specified by the owner (engineer) prior to the letting of the contract. The asphalt material for priming the subgrade shall be (*type and grade*) as specified prior to the letting of the contract. The asphalt material selected shall meet the requirements of the applicable table in *Specifications for Asphalt Cements and Liquid Asphalts,* Specification Series No. 2, The Asphalt Institute. A certificate of compliance with the specifications of the asphalt material will be acceptable.

10. *Mineral Aggregate: Asphalt Plant Mix Base and Surface*

(1) The mineral aggregate for asphalt plant mix shall consist of coarse aggregate, fine aggregate, and, if needed, mineral filler. The coarse aggregate shall be sound, angular crushed stone, crushed gravel, or crushed slag. Uncrushed coarse aggregate may be used in base course mixtures if the mixture meets all design criteria. The fine aggregate shall be well graded, moderately sharp to sharp sands.

(2) The mineral aggregate and asphalt shall be combined to meet the following gradations for asphalt plant mix base and surface, as specified by the engineer prior to the letting of the contract.

Base and Surface Sieve Size	* *Percent Passing by Weight*
¾ in.	_____
⅜ in.	_____
No. 4	_____
No. 8	_____
No. 30	_____
No. 50	_____
No. 100	_____
No. 200	_____
Asphalt (Percent by weight of total mix)	_____

* Figures to be filled in. See Item 9, Notes to the Owner (Engineer).

C. *Construction*

11. *Spreading Base and Surface Courses: Asphalt Base and Surface*

(1) For all areas of more than 1,000 sq. yds., asphalt base and surface courses shall be spread and struck off with a paver. Any irregularities in the surface of the pavement course shall be corrected directly behind the paver. Excess material forming high spots shall be removed with a shovel or a lute. Indented areas shall be filled with hot mix and smoothed with a lute or the edge of a shovel being pulled over the surface. Casting of mix over such areas shall not be permitted.

(2) If it is impractical to use a paver or spread box in areas of 1,000 square yards or less, asphalt base and surface courses may be spread and finished by hand. Wood or steel forms, rigidly supported to assure correct grade and cross-section, may be used. Placing by hand shall be performed carefully to avoid segregation of the mix. Broadcasting of the material shall not be permitted. Any lumps that do not break down readily shall be removed.

12. *Compaction: Asphalt Base and Surface*—Rolling shall start as soon as the hot mix material can be compacted without displacement. Rolling shall continue until thoroughly compacted and all roller marks have disappeared.

In areas too small for the roller a vibrating plate compactor or hand tamper shall be used to achieve thorough compaction.

13. *Method of Measurement:* The quantities to be paid for will be as follows:

(1) *Preparation of Subgrade*—Total number of square yards of subgrade actually prepared for covering with base material.

(2) *Asphalt Mixture*—Total number of tons of asphalt mixture actually incorporated into the work.

14. *Basis of Payment:* The quantities enumerated in Section 13 will be paid for at the contract unit price bid for each item or at a lump sum price bid for the job. Payment will be in full compensation for furnishing, hauling and placing materials, for rolling, and for all labor and use of equipment, tools, and incidentals necessary to complete the work in accordance with these specifications.